Ecological Risk Assessment
Residual Risk Assessment
Willamette Cove Upland Facility

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LIST OF ACRONYMS

90UCL	90th percentile Upper Confidence Limit
µm	Micrometer
µg/dL	Microgram per deciliter
ac	Acre
ACA	Ash Creek Associates
amsl	Above mean sea level
AOCs	Areas of Concern
AST	Aboveground Storage Tank
BBL	Blasland, Bouck & Lee, Inc.
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
BNSF	Burlington Northern Santa Fe
BRA	Baseline Risk Assessment
BW	Body weight
CA	Contaminated Area
COIs	Contaminants of Interest
CPD	Commission of Public Docks
CPECs	Contaminants of Potential Ecological Concern
CRA	Comprehensive Risk Assessment
CSM	Conceptual Site Model
DEQ	Department of Environmental Quality
DU	Decision Units
EBV	Ecological Benchmark Value
EcoSSL	Ecological Soil Screening Level
ECSI	Environmental Cleanup Site Information
EPA	United States Environmental Protection Agency
EPCs	Exposure Point Concentrations
ERA	Ecological Risk Assessment
ESLs	Ecological Screening Levels
EU	Exposure Unit
FE	Formation Environmental, LLC
FS	Feasibility Study
ft	Feet
g/day	Grams per day
ha	Hectare
HEAST	Health Effects Assessment Summary Tables
IEUBK	Integrated Exposure Uptake Biokinetic
IH	Heavy Industrial
LC_{50}	Median lethal concentration
LD_{50}	Median lethal dose
LOAEL	Lowest-observed-adverse-effect-level
LWG	Lower Willamette Group
MDCs	Maximum Detected Concentrations
mg/kg	Milligram per kilogram
mg/dL	Milligram per deciliter
mg/L	Milligram per liter
MHWM	Mean High Water Mark

LIST OF ACRONYMS (CONTINUED)

MRL	Maximum Reporting Limit
NF	NewFields
NGVD29	National Geodetic Vertical Datum of 1929
NOAEL	No-observed-adverse-effects-level
OAR	Oregon Administrative Rule
OLLW	Ordinary Line of Low Water
ORNHIC	Oregon Natural Heritage Information Center
ORNL	Oak Ridge National Laboratories
OS	Open Space
PAHs	Polynuclear Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PDC	Portland Development Commission
PMC	Portland Manufacturing Company
PRGs	Preliminary Remediation Goals
RERA	Residual Ecological Risk Assessment
RI	Remedial Investigation
SCE	Source Control Evaluation
SLVs	Screening Level Values
SOW	Scope of Work
SVOCs	Semivolatile Organic Compounds
T/E	Threatened and Endangered
TMDP	Technical-Management Decision Point
TPHs	Total Petroleum Hydrocarbons
TRVs	Toxicity Reference Values
TQ	Toxicity Quotient
UPRR	Union Pacific Railroad
USDOE	U.S. Department of Energy
USTs	Underground Storage Tanks
VCP	Voluntary Cleanup Program
VOCs	Volatile Organic Compounds

1.0 INTRODUCTION

This document presents the residual ecological risk assessment (RERA) for the Willamette Cove Upland Facility (Facility). This document is a supplemental evaluation to the Ecological Risk Assessment portion of the Baseline Risk Assessment (BRA) that was conducted in 2007 (NewFields/Ash Creek Associates [NF/ACA] 2007). The BRA included analysis of risk for human health and ecological receptors at the Facility. This document does not contain evaluation of human health but is being submitted in conjunction with a Residual Human Health Risk Assessment (RHHRA) (Formation Environmental [FE]/ACA, submitted February 2013). The requirement and scope for the RERA are based on comments from Oregon Department of Environmental Quality's (DEQ) reassessment of the BERA (DEQ 2010, 2011, 2012a, 2012b; Formation 2012a, 2012b); correspondence between the Port and DEQ is presented in Appendix A and will hereafter be cited as "Port/DEQ correspondence, Appendix A." The additional scope includes incorporation of new data collected to support the Source Control Evaluation (SCE). The document was prepared on behalf of the Port of Portland (the Port) and Metro to satisfy (in part) requirements of the Voluntary Cleanup Program (VCP) Agreement (ECNWR-00-26) between the Port, Metro and the Oregon DEQ. The Facility is owned by Metro.

According to Oregon rules, an RERA is performed to supplement a Feasibility Study (FS) for a contaminated site to help identify the appropriate remedial action (OAR 340-122-0084(4)). The RERA estimates the residual risk associated with remedial alternatives and can be quantitative or qualitative (DEQ 2006b [FS guidance]). In the case of the Willamette Cove Upland Facility, DEQ approved the BERA, but requested fundamental changes to the risk assessment approach presented in the BERA, including (See Port/DEQ correspondence, Appendix A):

- Division of the site into four exposure units (EUs) (instead of one)
- Addition of two EUs along the shoreline of the Willamette River
- Addition of mammals to the detailed exposure and risk analysis
- Incorporating results of sampling conducted after the 2008 removal action (Central Parcel), results of beach samples from the Portland Harbor Superfund Site Remedial Investigation to be evaluated as part of the surface soil dataset, and the results of additional sampling and risk analysis for dioxins

- Changing exposure parameters for avian receptors

Based on these requests, the scope of the RERA is essentially equivalent to a full quantitative Baseline ERA, including re-screening of chemicals of interest (COIs) for each of the six exposure units. As a result, the structure of this RERA is based upon the process prescribed by DEQ in the *Guidance for Ecological Risk Assessment: Levels I, II, III, IV* (DEQ 2001).

The BERA (NF/ACA 2007) included a Level 1 ERA analysis for the site which indicated the presence of hazardous substances and potentially complete exposure pathways for ecological receptors. The BERA also included a Level II screening-level analysis, as well as an expanded analysis intended to address questions more related to DEQ's Level III analysis. The BERA was based on exposure estimated on Facility-wide basis, and concluded that risk at the Facility generally did not exceed Oregon acceptable risk levels (ARLs). However, DEQ subsequently requested risk analysis for the site be conducted separately for the three tax parcels (Port/DEQ correspondence, Appendix A). Subsequent requests added the Central Beach EU, the Inner Cove EU, and the Wharf Road EU (Port/DEQ correspondence, Appendix A). DEQ requested additional analysis that includes separate risk calculations for each of these units. The requested analysis is presented in this document.

Section 1 summarizes background information on the history and regulatory status of the site. The problem formulation and Level II Screening are presented in Section 2. The expanded exposure and risk calculation methods are described in Section 3, while the exposure analysis and risk characterization are presented in Section 4. Section 5 presents the overall conclusions and recommendations.

1.1 Facility Description

The Facility is located along the northeast bank of the Willamette River in the St. Johns section of Portland, Oregon between River Miles 6 and 7 (mostly in Section 12 of Township 1 North, Range 1 West, Willamette Meridian) (Figure 1-1). The DEQ Environmental Cleanup Site Information (ECSI) identification number for the Facility is 2066.

The Facility is bordered on the northeast by the Union Pacific Railroad (UPRR) right-of-way (Figure 1-2). Farther to the northeast is a vegetation-covered bluff that rises about 30 to 80 feet in elevation above the Facility. A residential area is present on top of the bluff and farther inland. On the southeast is an embankment for the Burlington Northern Santa Fe (BNSF) railroad bridge over the Willamette River. South of the BNSF embankment is the former McCormick & Baxter Creosoting Company, a federal Superfund Site. Adjacent to the northwest side of the Facility is a vacated portion of North Richmond Avenue. The Facility is bordered on the southwest by the Willamette River. The 'cove' adjacent to the eastern portion of the Facility (i.e., Willamette Cove) is a part of the river that is set back from the main river channel up to 800 feet. Figure 1-2 shows aerial photography from 2011 and identifies current features at the Facility, including the six exposure units.

1.2 Facility History

The Willamette Cove Upland Facility is currently owned by Metro. Metro acquired the property in 1996 for the purpose of creating a green space area to be used as a public park. Historically, Willamette Cove consisted of three separate "parcels" (West, Central, and East), each of which had different ownership and activities. Figure 1-2 shows the locations of the three parcels at the Facility. Details on the Facility history were previously provided in the Existing Data/Site History Report (Hart Crowser 2000) and in the Final Draft Remedial Investigation Addendum: Supplemental Preliminary Assessment of the Willamette Cove Upland Facility (Port 2003). Since the time of those reports, additional historical information about the Facility has been obtained. An updated summary of each parcel's history is provided below.

West Parcel. The West Parcel consists of approximately 5 acres and is the westernmost property of the Willamette Cove Upland Facility. The Port never owned or operated the West Parcel. Prior to 1901, the West Parcel was either undeveloped shoreline or used for residential purposes. An 1855 map shows the William Caples homestead was situated near the present-day intersection of North Richmond Avenue and the UPRR tracks. From about 1901 through 1963, the West Parcel was occupied by a plywood manufacturing plant. Historical maps indicate the early plant was relatively small, consisting only of a few buildings (a 1906 drawing shows three buildings and a dock) (Portland & Seattle Railway 1906). In February 1910, the plant burned to the ground, destroying the equipment and building. The plant was rebuilt and resumed plywood production in the fall of 1910. Available public records reflect that at full build-out, the plywood plant contained a glue mixing room, wood presses, an oil house, blacksmith shop, grinding room, and two debarkers. Many of these structures were built on piers or were directly adjacent to the waterfront. In addition, the central portion of the West Parcel and the adjacent river area were used as a log pond to store the logs used in the plywood mill.

The plywood manufacturing plant was operated by Portland Manufacturing Company (PMC) under various ownerships. PMC produced wood products including baskets, crates, wood drums, and excelsior (wood shavings for packing). In 1963, the plant was shut down and woodworking operations were discontinued. PMC and its affiliates or successors (culminating as Simpson Timber) owned the West Parcel until 1964, when it was sold to Portland Lumber Mills. Brand-S Corporation became owner via a merger with Portland Lumber Mills in 1966. After the plant shut down in 1963, a few buildings were used for sawmill operations. About 1972, all buildings on the West Parcel were demolished. By 1976, the former log pond on the parcel was filled. Since then, no development has occurred. The City of Portland, through the Portland Development Commission (City PDC), purchased the West Parcel from Brand-S in 1979. As previously mentioned, Metro acquired the West Parcel in 1996.

Central Parcel. The Central Parcel consists of approximately 11 acres and is situated in the center of the Facility between the West and East Parcels. Prior to 1900, most of the Central Parcel was submerged land. Maps of the area from the late 1800s show the bluff that is currently northeast of the Central Parcel extended directly to the river. As such, the Central Parcel upland did not exist historically (or if it did, it was riverbank along the present day UPRR tracks). In the 1920s, fill was placed between the dry docks (discussed below) and the UPRR tracks, creating the Central Parcel upland.

The Port acquired the Central Parcel in 1903. From 1903 through 1953, the St. Johns Dry Docks were located adjacent to the Central Parcel. The St. Johns Dry Docks was a “common user” plant, reputedly the only one of its kind in the United States, and was provided as a public service to support the commerce of the state. Oregon law forbade the Port to conduct repair activities and specified that “dry docks shall be kept open to all ship repairers and mechanics on equal terms”.

Initially, the dry dock complex consisted of a single dry dock with a 10,000-ton lifting capacity (Dry Dock 1). Dry Dock 1 was installed in 1904 and was situated approximately 200 feet from the riverbank. Two piers along the dry dock extended westward about 280 and 740 feet from the dry dock. Shore access to Dry Dock 1 was on a 22-foot-wide pier located in the eastern portion of the

Central Parcel. A second dry dock was constructed by the City Commission of Public Docks (City CPD) in 1921 and was positioned along the south side of Dry Dock 1. The new dry dock (Dry Dock 2) was larger than Dry Dock 1 and had a 15,000-ton lifting capacity. The City CPD was the initial owner of Dry Dock 2 and retained the maintenance responsibilities until ownership was transferred to the Port in 1923.

Between 1903 and 1918, other than the access pier, there were no buildings on the Central Parcel. Between 1907 and 1908, a small building with space allocated for an air compressor was constructed on the dry dock to be used as a blacksmith shop. Between 1915 and 1916, a new roadway to the dry dock was completed. A Power House with a 15,000-gallon steel aboveground storage tank (AST) for oil was built in 1904 and located directly north of the Central Parcel (i.e., offsite) (Oregonian 1904). The Power House was dismantled and use of the oil tank discontinued by September 1939.

In 1918, an overwater coaling dock with a rail spur was constructed about 100 feet from the riverbank. The coal dock was provided as a public service by the Port for use by private companies and the United States. The Port charged a tariff to allow private companies and the United States to handle and store coal at the wharf (Oregonian 1919). By 1924, use of the wharf for coal was discontinued and it was being used primarily for storage of machinery. Removal of the coaling wharf was initiated in 1934, and completed by December 1935.

Between 1918 and 1924, the Central Parcel was further developed with storage buildings; blacksmith, pipe, woodworking, and machine shops; a restaurant; an automobile garage; and a pattern loft. In 1921-22, an Auxiliary Plant was constructed at the dry docks for the ship repair contractors. Between 1924 and 1932, the 740-ft pier structure closest to the river bank was reconstructed with a new shorter dock (~400 feet long) and was straightened to be parallel to the other docks. The 1932 Sanborn map shows a warehouse and an additional blacksmith shop were constructed at the east end of the Central Parcel. Around 1939, the northwestern portion of the Central Parcel was used for storage. Between 1939 and 1948, the lawn at the southeast end of the Central Parcel was converted to an unpaved parking area. By 1953, operation of the St. Johns Dry Docks ceased and the dry docks were relocated to Swan Island.

In 1950, two of the three Central Parcel tax lots (99 and 124) were acquired by PMC, the owner of the adjacent West Parcel (prior to 1950, PMC had used the northeast portion of these tax lots). In May 1953, Harold Scritsmier acquired tax lot 39 and purchased the in-river dock structures from the Port. Scritsmier constructed a sawmill at the north access pier. The Scritsmier plant consisted of a sawmill, filing room, shaving hopper, shaving bin, wharf with a rail spur, and green chain. Many of the structures formerly constructed in support of the dry docks were used in sawmill activities. By 1957, a few of the buildings were demolished, including the warehouse in the northwestern portion of the Central Parcel. In 1962, the large shop building was partially demolished, and then was damaged by fire. By 1965, the sawmill operations were significantly reduced and Scritsmier began leasing portions of the Central Parcel to private tenants. By 1970, the sawmill was no longer in use. The City PDC acquired the Central Parcel in 1981 and demolished the existing structures in the early 1980s. The Central Parcel has been vacant since that time. As previously mentioned, Metro acquired the Central Parcel in 1996.

East Parcel. The East Parcel consists of approximately 16 acres and occupies the southeastern most portion of the Willamette Cove Upland Facility. The Port never owned or operated the East Parcel. The East Parcel was originally lowland and wetland areas when it was acquired in 1900 by Western Timber Company. Western Cooperage, Inc. purchased the East Parcel in 1907 for the development of a general cooperage plant for manufacturing staves, barrels, kegs, lumber, shingles, and other timber products. In developing the East Parcel, Western Cooperage had the low-lying land filled up to 30 feet with dredged material. Construction was complete and the cooperage plant was in operation by 1915. The plant features included a grinding room, oil house, transformer house, battery charging room, glue mixing/gluing/press room, machine shop, overwater log lift debarker, and saw filing room; logs used in the cooperage were stored in Willamette Cove.

Western Cooperage manufactured barrels until the 1950s, when declining demand led to a focus on plywood production. By the end of the 1950s, log and timber supplies were no longer economical to transport to the area for processing. Aerial photographs indicate that the sawdust loading dock and connecting railway were demolished by 1957. In addition, aerial photographs and the 1963 city directory indicate that the mill was no longer operating. The East Parcel was sold to Western Associates in 1957. During the 1960s and 1970s, the large warehouse on the parcel continued to be used by other small businesses, including Flakewood, Inc., who continued to manufacture plywood at the property until 1967. In October 1967, a large fire destroyed much of the plant (Oregonian 1967).

Most of the cooperage buildings were demolished between 1968 and 1971. Large log rafts were observed moored in the Cove after cooperage operations ceased through the 1970s, possibly storing logs for the McCormick & Baxter Creosoting Company.

The East Parcel was sold to West Coast Orient Company in 1975. The City PDC acquired the East Parcel in 1980. The City PDC removed the large warehouse by June 1981. As previously mentioned, Metro acquired the East Parcel in 1996. In 2004, DEQ removed wooden and concrete dock pilings and a derelict barge from the near shore area in response to mitigation requirements for the McCormick & Baxter Superfund Site cleanup.

1.3 Regulatory Status

Investigation activities are being conducted at the Facility under a VCP Agreement (ECNWR-00-26) for Remedial Investigation and Source Control Measures, effective November 4, 2000. This agreement is between the Port, Metro, and DEQ.

The scope of the risk assessments is limited to the upland portion of the Facility. The Facility is defined by the property boundaries and Mean High Water Mark (MHWM); 13.3 feet above mean sea level [ft amsl] North American Vertical Datum of 1988 [NAVD88]), as described in the VCP Agreement.

1.4 Summary of Investigations

Several environmental investigations have been performed at and near the Facility, including the adjacent shoreline and river sediments. A detailed discussion of these investigations and their findings are presented in the Existing Data/Site History report (Hart Crowser 2000) and the Remedial Investigation (RI) report (Hart Crowser 2003). A brief summary of these, and subsequent investigations is provided below.

Prior to 2001, two environmental investigations (Sweet Edwards/EMCON, Inc. 1989, 1996) and an underground storage tank (UST) removal (Hahn and Associates 1999) were performed at the Facility. Samples were also collected from the Willamette Cove Upland Facility as part of studies of the adjacent McCormick & Baxter Superfund Facility (PTI Environmental Services 1992; Ecology and

Environment 2000). The results of these investigations were analyzed as part of Phase I activities and are discussed in the RI report (Hart Crowser 2003).

From April 2001 through September 2002, Hart Crowser performed Phase II RI activities at the Facility to characterize the nature and extent of chemical contamination in soil and groundwater. The RI activities included completing 26 test pits, 30 push probes, and seven hand-augered soil borings; collecting 35 surface soil samples; installing seven groundwater monitoring wells; and performing two groundwater monitoring events. In addition, the extent of debris on cove beaches was mapped and the upland area and riverbank were inspected for erosion. In a letter dated December 20, 2003, DEQ provided comments on the RI report to the Port. Several of DEQ's comments expressed concern about potentially erodible soil on the riverbank at the Facility. DEQ also requested additional groundwater sampling.

In response to DEQ's comments, two additional groundwater sampling events were performed at the Facility in September and December 2005. The results are documented in the Groundwater Monitoring Report – Third Quarter 2005, (Blasland, Bouck, and Lee, Inc./Ash Creek Associates/NewFields [BBL/ACA/NF] 2005a) and Groundwater Monitoring Report – December 2005 (BBL/ACA/NF 2006a).

In addition, riverbank sampling was performed in December 2005 to address DEQ's comments regarding the potentially erodible soil on the riverbank of the Facility. Sampling was performed as outlined in the Riverbank Soil Sampling Work Plan (BBL/ACA/NF 2005b). The samples were analyzed for polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and metals and the results were presented in the Riverbank Soil Sampling Report (BBL/ACA/NF 2006b). PCBs were detected in one area of potentially erodible soil on the western portion of the East Parcel; however, the extent was not defined. A follow-up field investigation was performed in 2007 to define the extent of PCBs in areas of potentially erodible soil at this location. The results are provided in the Riverbank Soil Sampling Addendum (ACA 2008a).

Additionally, in a letter dated October 18, 2006, DEQ requested that the southern property boundary be surveyed to more accurately define the boundary between a BNSF railroad right-of-way and the Facility. The results of the survey are provided in the Riverbank Soil Sampling Addendum (ACA 2008a).

In 2007, soil sampling was performed to support removal action activities that were recommended in the Baseline Risk Assessment (ACA/NF 2007). The removal action was conducted to excavate surface soil that contained elevated metals and mitigate potential ecological risk. The work was completed in 2008 and the results are presented in the Removal Action report (ACA 2008b).

Additional sampling of the riverbank and beach soil was conducted in 2010. In addition, four exploratory trenches on the beach portion of the East Parcel were excavated and grab samples of soil and groundwater were obtained and analyzed for petroleum hydrocarbons and PCBs. The results are presented in the Source Control Sampling Results letter report (ACA 2011).

Lastly, dioxins were recently identified in one area of non-erodible soil near the former road leading onto the wharf (ACA 2011). Additional surface soil sampling at the Former Wharf Road Area was conducted in August 2012 in accordance with DEQ's approved work plan, *Revision to Proposed Surface Soil Sampling- Former Wharf Road Area* (dated June 25, 2012), as cited in ACA 2012. Surface samples were collected from three decision unit areas using an incremental soil sampling technique. Soil samples were analyzed for extent of dioxins/furans (ACA 2012).

The sampling events outlined above provide a comprehensive dataset that adequately characterizes the soil and groundwater conditions at the Facility. COIs and potential areas of concern (AOCs) were identified from the historical use review (Hart Crowser 2000) and previous investigations as summarized above. Results of the RI indicated the presence of some COIs in soil and groundwater. The BRA (NF/ACA 2007), and RHHRA (FE/ACA, Draft Submitted January 2013) evaluated the potential risks to human health from COIs in Facility soil and groundwater to potential human receptors. As indicated in the introduction, the RERA presented in this document further evaluates the potential risks posed by the presence of these COIs in Facility surface soil to potential ecological receptors.

This RERA uses these data for risk evaluations because this dataset is relevant, current, and of known data quality suitable for risk assessment purposes.

1.5 Facility Land and/or Water Uses

1.5.1 Current Uses

The Facility is currently vacant, covered with invasive and native vegetation, and provides habitat for opportunistic use by wildlife. The Facility is not managed for any human use and is posted to prohibit trespassing. However, trespassers do come on site (e.g., homeless persons and joggers).

The Facility is currently zoned as an Open Space (OS) zone with “g” (River General) and “q” (River Water Quality) greenway overlay zones (City of Portland 2004). The OS zone is intended to preserve and enhance public and private open, natural, and improved park and recreational areas. Greenway regulations are also intended to protect, conserve, enhance, and maintain the natural, scenic, historical, economic, and recreational qualities of lands along Portland’s rivers. Specifically, the “g” overlay is intended to allow public use and enjoyment of the waterfront and for enhancement of the river’s scenic and natural qualities. The “q” overlay is designed to protect the functional values of water quality resources by limiting or mitigating the impact of development in the 25-foot setback from the top of bank. Other nearby zoning includes commercial (EG2), residential (R2 and R5), open space (OS), and industrial (IH and IG2) (City of Portland 2004).

The Facility was included in a citywide inventory which identified three scenic resources at or near the Facility (City of Portland 2000). First, the entire Willamette River through Portland was designated as a scenic corridor, offering outstanding views of the West Hills, bridges, and riverfront natural areas. Second, a scenic viewpoint was identified on the Facility, looking northward to the St. Johns Bridge. Viewpoints provide locations where the public can enjoy the natural and built environment. Third, Willamette Boulevard, on the bluff northeast of Willamette Cove, was also designated as a scenic corridor, with views of the river, the city, and the West Hills.

1.5.2 Future Uses

Portland Parks and Recreation has prepared a draft management plan for the Willamette Cove Upland Facility (City of Portland 1999). This report indicates that one potential plan for the Facility would be an urban natural area with passive recreation opportunities (i.e., a park). The plan includes a “Cottonwood Forest” zone in the East Parcel which would have clusters of large trees, a natural-resources education area for children, a rustic picnic area, bird watching opportunities, and a parking lot for up to 40 vehicles. The Portland Bureau of Parks and Recreation has also identified the need for a park in this area, listing both Willamette Cove and the McCormick & Baxter Superfund Facility as potential locations (after cleanup) for natural areas, river access, and recreation (City of Portland 2001).

The Facility is included in a citywide inventory that identified scenic resources at the Facility (City of Portland 2012). The Facility is identified as a scenic viewpoint. The zoning map shows a recreational trail through the Facility (City of Portland 2004). However, this trail is only proposed as part of the regional trail plan adopted by Metro (Alta Planning and Design 2010).

Therefore, the reasonably likely future use of the Facility is for recreation. The actual site plan and type of recreational use or development is not known at this time. Until redevelopment for recreational purposes is initiated, current land use of the Facility is not anticipated to change.

1.6 Facility Cleanup Actions

Three cleanup actions have been performed at the Facility, including one in 1999 on the West Parcel, a second in 2004 on the East Parcel, and a third in 2008 on the Central Parcel. Details on the July 1999 cleanup action can be found in a report prepared by Hahn and Associates (1999); details on the 2004 removal action are contained in a memorandum prepared by ACA/Hart Crowser (2005); and details on the 2008 removal action are contained in a removal action report prepared by ACA/NF (2008b). The following summarizes the results of the actions:

- Several gallons of black tarry oil were observed on the ground surface of the West Parcel during brush clearing activities in July 1999. The oil and associated petroleum-contaminated soil (about 127 tons) were removed and transported off the property for treatment. During the removal, a 12,000-gallon UST was discovered at a depth of 7 feet. The UST was subsequently removed from the West Parcel (Hahn and Associates 1999). The excavation was backfilled by grading soil from the surrounding area into the excavation.
- On July 6, 2004, a product sheen was observed at Willamette Cove during implementation of the remedial action at the McCormick & Baxter Creosoting Company

Superfund Facility (McCormick & Baxter Facility). Test pits in soil directly above the ordinary line of low water indicated the presence of petroleum product. A removal action was performed in accordance with the October 5, 2004, Scope of Work (SOW) prepared by the Port and Metro and approved by DEQ. The removal action defined the extent of the petroleum product and removed the mobile petroleum product from Metro's property to the extent practicable through soil excavation.

- A removal action consisting of excavation and off-site disposal of metals-impacted soil was completed in June 2008. The purpose of this removal action was to remove soils with lead and other metals to decrease residual risks to ecological receptors. A limited area on the eastern portion of the Central Parcel contained elevated concentrations of lead and other metals in surface soils. Although the baseline risk assessment (NF/ACA 2007) did not identify unacceptable risk associated with the metals from an overall site perspective, a removal action to excavate and dispose of these soils off-site was performed to reduce the likelihood of localized adverse effects to plants, birds, or mammals in the eastern Central Parcel. A total of approximately 987 tons of soils containing lead and other metals were removed from the Facility and disposed at the Waste Management's Hillsboro landfill. This included 356 tons of soil that was stabilized prior to disposal to remove the hazardous characteristic and 631 tons of soil that did not require stabilization before disposal. Relative concentration reductions for arsenic, chromium, copper, and lead were calculated to provide a semi-quantitative measure of the removal effectiveness. Concentrations of these metals were reduced between 56% and 99.5% as a result of the action (ACA 2008c).

2.0 ECOLOGICAL SITE DESCRIPTION, CSM, LEVEL II SCREENING

The ERA process for the Willamette Cove Upland Facility is based upon the process prescribed by DEQ in the *Guidance for Ecological Risk Assessment: Levels I, II, III, IV* (DEQ 2001). The guidance describes a sequence for conducting ERAs, beginning with Level I Scoping. The purpose of the Level I Scoping ERA is to provide a qualitative determination of whether there is reason to believe that ecological receptors and/or exposure pathways are present at the Facility (DEQ 2001). The Level I analysis includes the Facility description as it relates to potentially contaminated environmental media, and the potential exposure to ecological receptors. The conclusion of the Level I analysis presented in the BERA (NF/ACA 2007) was that hazardous substances are potentially present, and ecological conditions at the site were such that receptors could be exposed. The Level I analysis is not repeated here, but the information site description provided with the Level I and II analysis in the BERA are presented to provide context for the exposure and risk analysis

2.1 Ecological Facility Description

An overall description of the location, physical features, current uses, and history of the Facility is presented in the RI report (Hart Crowser 2003). The following sections are intended to supplement that information for elements relevant to the Level I Scoping and Level II Screening.

The Portland area has a temperate marine climate characterized by mild, wet winters and moderately warm, dry summers. According to Oregon State University's Oregon Weather and Climate Data Website (2003), precipitation averages 36 inches per year, with approximately 75% of the precipitation occurring between October 1 and March 31. Monthly average temperatures range from a low of approximately 34°F in January to a high of approximately 80°F in July and August.

The VCP describes the Facility as being comprised of 27 acres (ac) of land surface, although this estimate may be slightly high. The shoreline with the Willamette River is approximately 3,900 linear feet (ft), based on interpretation of an aerial photo from May 2002. The land surface and shorelines may vary somewhat as water levels in the river change. According to the City of Portland (2000), the existing vegetation communities at the Facility include bottomland forest (approximately [~] 11 ac), upland shrub (~13 ac), dry meadow (~1 ac), and wet meadow (~1.5 ac) (Figure 2-1). The remainder is riverbank/beach area. However, a significant portion of the East and Central (eastern one-half) Parcels is ruderal, with large tracts of barren ground and weedy species.

The bottomland forest areas occur within a narrow corridor along the length of the Facility. These areas are dominated by young black cottonwood trees and non-native tree species, such as Lombardy poplar, catalpa, and holly (City of Portland 2000). Other species include Pacific willow, cherry, and birch. Many of the ornamental and non-native tree species were apparently planted on the former building grounds. The understory of the bottomland forest area is dominated by invasive species such as Himalayan blackberry, English ivy, clematis, and reed canarygrass which suppress plant diversity in the understory areas, especially along the river bank and in edge areas. The forest area is bisected in areas by well-worn and compacted dirt trails (City of Portland 2000).

The meadow area at the northwest end of the Facility (i.e., West Parcel) is fairly open and includes mesic and dry sections. Herbaceous vegetation in these areas is dominated by weedy grass and herb species, such as Queen Anne's lace, reed canarygrass, nightshade, crabgrass, horsetail, vetch species, and timothy grass (City of Portland 2000).

The scrub-shrub area in the Central and East Parcels is characterized by Scot's broom, Himalayan blackberry, Indian plum, native hawthorn, elderberry, and sumac (City of Portland 2000). The ruderal portions of the Central and East Parcels are open areas with weedy grass and herb species. There are also ornamental and non-native tree species that were apparently planted on the former building grounds. The open areas show signs of disturbance including packed vehicle and foot trails, parking areas, and ruins from former industrial facilities. The open areas in the middle of the Central Parcel show signs of disturbance of two activities in 2005 and 2008. In 2005, the area was used for stockpiling materials and staging area for upland capping activities at the McCormick and Baxter Superfund Site. That area in the Central Parcel was graded with new fill (M&B upland cap material) and is being colonized by grasses and blackberry. In 2008, the Port conducted a voluntary removal action on a small area (987 tons from < 1 ac) to address elevated metals concentrations in soils (ACA/NF 2008b). That area partially overlaps with the area that was regraded after the McCormick and Baxter stockpiling.

Much of the riverbank along the West and Central parcels is high (20-30 ft. in some places) and steep. In some areas, the bank is heavily armored with rip-rap. There is a wooden seawall along the shoreline at the upstream end of the Central parcel. The shoreline of the East parcel is largely beach that extends around the most inset part of the cove. As part of the remedy at the McCormick and Baxter site, a sand cap with an armored surface was installed along much of southern shoreline of the cove. This armoring was covered with sand and gravels, but the armoring is visible in some areas (Figure 2-1).

No formal wildlife surveys have been conducted for the Facility. During Facility visits, various songbirds (including American robin, brewer's blackbirds, and song sparrows) and red-tailed hawks have been observed. No mammalian wildlife, or signs thereof, were observed during Facility visits, but it is likely that small rodents such as mice and voles are resident, and urban-adapted species such as raccoons and fox squirrels probably frequent the Facility. As a relatively isolated, 27 ac parcel, the Facility is too small to harbor resident deer, fox, or coyote. However, such species may visit the Facility during movements through vegetated corridors in the area.

The Willamette River is adjacent to the Facility, but no permanent surface water bodies are present on the Facility. Along this reach, the river flows to the northwest and is about 1,300 feet wide. Willamette Cove is an embayment of the Willamette River and is set in up to 800 feet from the main river channel.

2.1.1 Sensitive Environments and Threatened and/or Endangered Species

Based on specific environments listed in OAR340-122-115 (50), and the Oregon Natural Heritage Information Center (ORNHIC) information on protected species, there are no sensitive environments at the Facility. The Facility is adjacent to the Willamette River, which is a sensitive habitat according to Oregon regulations because it harbors protected fish and wildlife species. A list of threatened and endangered (T/E) species potentially present in the area was provided by ORNHIC in 2007. At the time, bald eagle and peregrine falcon were identified as potentially present, but none had been observed. Both species have since been de-listed. No other listed species have been identified and the Facility does not contain critical habitat features for currently listed terrestrial species. The Willamette River contains habitat for several fish species of interest, including green sturgeon, chinook salmon, coho salmon, and steelhead. The Facility does not provide aquatic habitat in which these fish species would be found, but there are potential pathways for transport of COIs to the river.

Exposure and risks of receptors in the Willamette River is outside the scope of this RERA (Refer to Section 2.3, Conceptual Site Model and Exposure Pathways).

2.2 Observed Impacts

No impacts on ecological receptors were observed at the Facility. No signs of toxic stress from COIs were observed during Facility visits. Such signs could include stressed or dead vegetation, patches of barren soil, or dead or dying animals that could not be explained based on other factors. Barren soil areas were observed in the East and Central parcels, but much of this area is hard-packed gravel surfaces that have experienced heavy vehicle traffic or are the former locations of buildings. In the Central and West Parcels, foot trails used by transients and joggers/hikers are largely devoid of vegetation in the most heavily used areas. Adjacent areas support grasses, herbaceous species, and shrubs, suggesting that stress to vegetation in barren areas is from physical factors.

2.3 Conceptual Site Model (CSM) and Exposure Pathways — Ecological

A conceptual site model (CSM) provides information about contaminant sources, release mechanisms, potential receptors, and exposure pathways at a site. Preliminary identification of potential exposure pathways for ecological receptors was outlined in a Preliminary CSM in the RI report (Hart Crowser 2003), and an updated CSM is presented as Figure 2-2. The CSM figure was modified from that shown in the RI report based on discussions with DEQ personnel in an April 12, 2005 meeting, comments submitted by DEQ on October 16, 2006 and subsequent Port/DEQ correspondence, Appendix A.

Modifications include identification of pathway/receptor categories that are being addressed through the Portland Harbor RI/FS risk assessment process. DEQ specified that the Willamette Cove Upland risk assessment should not include the exposure pathways being evaluated in the Portland Harbor RI/FS. As a result, this risk assessment will not address risk to ecological receptors from direct contact with contaminants in beach sediments, surface water or sediment in the Willamette River; or bioaccumulation of COIs from surface water or sediments.

DEQ also requested that the Upland Facility Risk Assessment not include pathways addressed in the formal Source Control Evaluation that the Port is preparing for this Facility. Therefore, this RERA does not address pathways potentially resulting from transport of Facility groundwater to surface water in the Willamette River, or transport of erodible riverbank soils to the river.

[Note that the RI report had identified the transport of COIs to the river via erodible riverbank soils as an incomplete pathway. Based on requests from DEQ in its December 20, 2003 letter to the Port, and subsequent investigation, a few erodible riverbank areas at the Facility have since been identified and this pathway is considered potentially complete in these limited areas. The possible effect of erodible soils on sediment and surface water quality in the Willamette River are characterized and evaluated separately as a part of a Source Control Evaluation and is not described further in this document.]

A general evaluation of potential ecological exposure pathways is provided in the Level I Scoping checklists in the BERA (BERA, Appendices A-1 and A-2). The primary contaminant sources and release mechanisms are release of chemicals to soil or impervious surfaces as a result of onsite or offsite operations.

The potentially complete ecological exposure pathways outlined in the CSM (and discussed in Hart Crowser 2003) that are a part of this risk assessment include the following:

Direct Exposure Pathways:

- direct contact with contaminated surface or subsurface soil through contact with external surfaces or ingestion (terrestrial receptors).

Indirect Exposure Pathways:

- ingestion of terrestrial food sources that have become contaminated through direct or indirect pathways (i.e., food web exposure).

Direct Contact with Contaminated Soils. Receptors may encounter contaminated soils at or near the ground surface. Direct contact includes potential ingestion or inhalation of dusts generated by wind or ground disturbance (e.g., traffic). Ecological receptors, such as invertebrates and burrowing small mammals, can be exposed by burrowing into contaminated soils.

Indirect Exposure to Contaminated Soil. Contaminants can be taken up by plants and invertebrates, and ingested by organisms in higher trophic levels.

Groundwater Exposures. Since shallow groundwater is approximately 25 and 30 feet bgs, no terrestrial receptors at the Facility are exposed to groundwater.

2.4 Exposure Units

The BERA treated the site as one exposure unit, and exposure point concentrations for the Level II screening were based on aggregation of data across the entire Facility. The BERA exposure and risk analysis were focused on the Central Parcel only, because the greatest potential for risk was from metal concentrations in soils in that parcel.

As a result of their re-evaluation of the BERA and defining scope for the RERA, DEQ requested that the site be divided into six EUs (Figure1-2):

1. West Parcel EU
2. Central Parcel EU
3. East Parcel EU
4. Inner Cove Beach EU
5. Central Beach EU
6. Wharf Road EU

The West Parcel, Central Parcel, and East Parcel are defined as the tax lots in the upland areas of the Facility, bounded by the MHWM on the riverward side of the parcels. The Inner Cove Beach EU is adjacent to the Central Parcel and East Parcel, and consists of the area between the MHMM and the ordinary line of low water (OLLW) in the interior cove area, and includes primarily the beaches and shoreline. The Central Beach EU is adjacent to the Central Parcel, between the MHWM and OLLW. The Inner Cove Beach EU and the Central Beach EU are not within the Facility Boundary as defined in the VCP, but are included in this RERA based on comments from DEQ (Port/DEQ correspondence, Appendix A).

The Wharf Road EU is defined by the three multi-incremental sampling decision units (DUs) developed for assessing the potential concentrations of PCDD/Fs in soils in the area formerly occupied by the access road from the upland area to the St. Johns dry docks. The area is small

(~0.34 acres) and likely does not constitute an area large enough to support small birds or mammals. However, risk calculations were performed using the PCDD/F data From the DUs.

Figures 2-2 through 2-7 show the surface soil sampling locations in each of the EUs. Data from these locations were used in the Level II screening described in the remainder of Section 2, and the expanded exposure and risk calculations in Section 3.

The BERA for the Portland Harbor Superfund Site (PH-BERA) (Windward 2011) evaluated risk for wading birds based on composite beach samples from the Inner Cove Beach EU and Central Beach EU. Results of the PH-BERA are included in the Risk Characterization discussion for these two EUs in Section 4.2.

2.5 Level II - Screening

2.5.1 Methods for Level II Screening

The ecotoxicological risk screen was conducted according to DEQ guidance for Level II Screening (DEQ 2001). DEQ guidance specifies several tasks when the Level II analysis is conducted independently. However, many of the tasks and much of the background information cited in the Level II guidance were addressed in the Level I evaluation (i.e., conduct site survey, provide site description, identify ecological receptors, and identify complete exposure pathways). Therefore, the analysis presented below focuses on the tasks that relate directly to conducting the Level II screen, including:

- evaluate data sufficiency (Task 1 of the guidance);
- identify candidate assessment endpoints (Task 6);
- identify known ecological effects (Task 7);
- calculate COI concentrations (Task 8); and
- identify contaminants of potential ecological concern (CPECs) (Task 9).

2.5.2 Data Available for Screening

Analytical results from the RI sampling (Hart Crowser 2003) and subsequent sampling events (e.g., BBL/ACA/NF 2005a, 2006a, 2006b, ACA/NF 2008b, c; ACA 2011, ACA 2012) provide a comprehensive dataset that adequately characterizes the current soil conditions at the Facility, and are sufficient to perform the screen for all portions of the Facility. Sampling locations are shown in Figures 2-3 through 2-7; data used for screening are shown in Appendix B.

In accordance with DEQ policy, data from soil samples to 3 feet bgs were included in the ecological risk screening analyses, to adequately account for surface exposure and potential exposure to burrowing animals. Analytical data for soil samples from less than 4 feet bgs are available for sampling locations in each of the EUs (Figure 2-3 through 2-7). The majority of the soil samples were collected during several field investigations conducted between 1988 and 2002 (Hart Crowser 2003). Soil samples were analyzed for COIs including a range of organic compounds and metals. Table 1 of the RI report (Hart Crowser 2003) lists the analyte suites for the RI samples. Nine results for benzo(b+k)fluoranthene from samples collected between 1991 and 2001 were excluded from the risk analysis because there were additional results for the individual isomers that were more conservative. Results for PAHs using method 8270-SIM were used preferentially over results obtained using method 8270 and results for phenols using method 8041 were used preferentially over results obtained using method 8270A.

In addition to RI sampling efforts, soil samples collected from riverbank sampling locations associated with the Source Control Evaluation were included (BBL/ACA/NF 2006b, ACA 2010a, b). The riverbank samples were collected as composite samples comprised of four sub-samples. Table 1 of the *Riverbank Soil Sampling Report* (BBL/ACA/NF 2006b) lists the analyte suites for each of the samples analyzed. Data from these riverbank soil sampling locations were used in conjunction with the rest of the dataset for the Level II comparison against SLV criteria.

All soil analytical results used in the ecological risk evaluations are listed in Appendix B.

2.5.3 Screening-Level Assessment Endpoints

According to DEQ guidance (2001), assessment endpoints are "…an explicit expression of a value deemed important to protect, operationally defined by an entity (hereafter, "endpoint receptor") and one or more of that entity's measurable attributes…" Assessment endpoints serve to focus the ERA on species and measures that are directly relevant to risk management decisions for a site. The assessment endpoints generally represent species or functional groups that are important to ecological function at a site, or rare species that have great ecological, aesthetic, or cultural value.

Assessment endpoints for a screening level assessment (e.g., Level II screening) are typically not as specific as those identified for baseline risk assessments where specific measures or data analysis methods are needed to make decisions. In addition, there are no T/E or other rare species known to use the Facility. For the DEQ Level II analysis, SLVs for soils and surface water have been identified for general groups of organisms including plants, invertebrates, birds, mammals, and aquatic receptors. The following candidate assessment endpoints were identified for the RERA:

- Survival and reproduction of terrestrial plants;
- Survival and reproduction of terrestrial invertebrates;
- Survival and reproduction of terrestrial-feeding birds;
- Survival and reproduction of carnivorous birds; and
- Survival and reproduction of terrestrial-feeding mammals.

2.5.4 Calculating COI Concentrations

Because wildlife receptors do not experience their environment on a "point" basis, environmental data for each COI need to be converted to an estimate of concentration over a habitat exposure area (DEQ 2001). Exposure-point concentrations (EPCs) are concentrations of COIs that represent a reasonable maximum exposure based on the media characteristics and site-specific receptors. The Level II guidance specifies that screening-level EPCs can be based on (1) site maximum detected concentrations (MDCs) for immobile or nearly immobile receptors (i.e., plants, soil invertebrates), or (2) 90%-upper confidence limits (90UCL) of the mean concentrations for more mobile wildlife receptors (i.e., birds, mammals) (DEQ 2001).

Only soil data were available for the risk screening. Soil samples from less than 4 feet bgs were included in the calculations to adequately account for exposure to potential burrowing animals. Riverbank soils (sampling locations SSA through SSY; see Figure 2-3 through 2-7) were included in the EPCs. Several samples were collected as composite samples comprised of sub-samples (e.g., SSE, SSH, A2C1). MDCs for all COIs were screened against background and screening level values (see below) before calculation of 90UCLs. If the MDC for a COI was less than the background value, then the COI was excluded as a CPEC.

For determining an MDC, all samples with detected concentration results for both composite and discrete, were included in the determination. For determining an EPC based on 90UCL, separate calculations were used for discrete and composite sample results, based on recommendations in the ProUCL guidance (EPA 2010). The EPA ProUCL computer program (EPA 2011) was used to calculate the 90UCLs for COIs that exceeded Level II screening criteria based on MDC. At least five data points were necessary before the term was calculated; otherwise only the maximum value was used. The 90UCL was calculated regardless of detection frequency. Each data set was first tested to determine the data distribution. If a normal distribution was identified, the 90UCL was calculated with the Student-t method. A gamma distribution was evaluated using the recommended gamma method provided in ProUCL. If a lognormal distribution was identified, the Chebyshev method was used for non-highly skewed data and the non-parametric Chebyshev method was used for highly skewed data. If the distribution could not be determined, the non-parametric Chebyshev method was used.

2.5.5 Frequency of Detection and Background Analysis

In accordance with DEQ guidance, COIs were screened based on comparison to regional background levels before being compared to toxicity SLVs, as outlined in Task 9 of the Level II guidance (DEQ 2001). The DEQ Level II guidance also includes screening out chemicals that are detected in less than 5% of samples. However, in its request for the RRA, DEQ requested that this criterion not be used for Willamette Cove (Port/DEQ correspondence, Appendix A). Regional background concentrations, as defined in DEQ guidance (Table 1 of DEQ 2010) were used to assess background for naturally occurring metals. DEQ does not consider organic chemicals as naturally occurring, and does not consider background screening in the CPEC identification process. If the MDC for a COI was less than the background value, then the COI was excluded as a CPEC.

2.5.6 Screening Level Values (SLVs)

SLVs published by DEQ (2001) for use in Level II analyses were used in the screening-level analysis, with some SLVs replaced by US EPA Eco Soil Screening Levels (Eco SSLs) (See Table 2-1). These values are based on no-observed-adverse-effects-levels (NOAELs) for each of the COIs. Therefore, if site concentrations are less than the SLV, no adverse effects are expected and no further analysis is required because risk is assumed to be negligible. The SLVs are based on intensive use of a site by receptors. Concentrations that exceed the SLV do not necessarily represent unacceptable risk, but indicate that additional evaluation of site conditions may be necessary to support risk management decisions.

2.6 Screening Results and Identification of Contaminants of Potential Ecological Concern (CPECs)

CPEC identification was conducted according to Task 9 of the DEQ guidance (DEQ 2001), including consideration of cumulative risk from multiple COIs, bioaccumulative toxins, and screening level availability. CPECs were identified by calculating the toxicity ratio (T) of the EPC (MDC or 90UCL) of each of the COIs to Level II SLVs (DEQ 2001). The guidance indicates two potential levels of analysis for soil COIs. For T/E species, the toxicity ratio is compared to the "receptor designator" (Q) value of 1 (i.e., if the Facility soil concentration exceeds the SLV, the constituent is identified as a CPEC). For non-protected species, T is compared to a Q value of 5 (i.e., if the Facility soil concentration exceeds five times the SLV [5x-], the constituent is identified as a CPEC). For completeness, both levels of results are presented in this document. However, CPECs are primarily identified for the Facility based on Q=5 because no T/E species are present at the Facility. CPECs identified at a Q=1 level are discussed with respect to carnivorous T/E bird receptors. In addition, potential risk to a receptor from multiple COIs simultaneously within a given medium was addressed by comparing T of an individual COI to the sum of T for all COIs.

2.6.1 Soil CPECs

2.6.1.1 Frequency of Detection and Background Analysis

Frequency of Detection: DEQ guidance (2001) advises eliminating any constituent reported as detected in less than 5% of samples from further risk evaluation, but based on DEQ comments (Port/DEQ correspondence, Appendix A), this RERA does not incorporate frequency of detection into the screening evaluation.

Background: The MDCs of naturally-occurring COIs are compared to default background values in DEQ guidance (Table 1 of DEQ 2010), and shown in Table 2-1. Those chemicals whose MDC was less than the default background concentration were automatically eliminated and not considered further in this RERA. This screening step applies to metals only and not to chemicals of anthropogenic origin (e.g., PAHs).

2.6.1.2 Screening Analysis

Identification of Candidate CPECs

Appendix D shows the results of the soil toxicity screens for each receptor (plants, inverts, birds, mammals) for each of the EUs based on COIs for which the MDC exceeded at least one SLV with a risk ratio (Q) greater than 5. These constituents are considered candidate CPECs that are subject to further analysis including calculation of 90UCLs and comparison to appropriate SLVs for each of the receptor groups. Chemicals that were not detected, but for which the highest non-detected result (i.e., highest detection limit) exceeded the screening levels, were retained in the screening tables. In addition, these tables include CPECs that were identified as a result of potential risk to a receptor from multiple COIs (DEQ 2001).

Comparison of MDCs to SLVs for Non-Wildlife Receptors

For plants and soil invertebrates (i.e., non-wildlife receptors), comparing the MDCs to the SLVs is an appropriate screening-level comparison (DEQ 2001), as these receptors are immobile or nearly immobile. Appendix D summarizes results of the soil toxicity screens based on comparison of MDCs to SLVs. In addition, the tables also indicate which MDCs exceeded SLVs with a risk ratio greater than 1, and which MDCs exceeded SLVs with a risk ratio greater than 5 (i.e., the MDC was greater than 5x-SLV). As noted above, the Facility does not have suitable habitat for T/E species, so a risk ratio of 5 corresponding to non-T/E species was used for identifying CPECs. A summary of CPECs exceeding SLVs are shown in Tables 2-2 through 2-7. Figures 2-8 to 2-16 show the locations at which CPEC concentrations exceed the plant or invertebrate SLVs CPECs exceeding plant or invertebrate SLVs at one or more locations were antimony, Aroclor (i.e., PCBs), chromium, copper, lead, mercury, nickel, HPAHs, vanadium, and zinc.

Comparison of 90UCLs to SLVs for Wildlife Receptors

For bird and mammal receptors (i.e., wildlife receptors), EPCs based on 90UCLs were calculated for all CPECs identified based on comparison of MDC to background concentrations and SLVs. Refer to Appendix D for the results of screens based on comparisons of the calculated 90UCLs to SLVs. Tables 2-2 through 2-7 summarize the results of the soil toxicity screens for each of the EUs based on comparison of 90UCLs to SLVs. The summary table indicates which 90UCLs exceeded SLVs with a risk ratio greater than 1, and which 90UCLs exceeded SLVs with a risk ratio greater than 5 (i.e., the 90UCL was greater than 5x-SLV). As noted above, a risk ratio of 5 corresponding to non-T/E species was used for identifying CPECs. CPECs exceeding wildlife SLVs were antimony, Aroclor (i.e., PCBs), barium, cadmium, chromium, copper, dioxin (TCDD equivalents), HPAHs, lead, mercury, nickel, vanadium, and zinc.

2.7 Technical-Management Decision Points (TMDPs) and Recommendations

Level II technical-management decision points (TMDPs) are steps in the risk assessment process where one of three recommendations is determined: 1) no further ecological investigations needed at a site; 2) continuation of the risk assessment process to the next level; or 3) undertake a removal or remedial action (DEQ 2001). The information gathered during the Level I Scoping and Level II Screening processes are used to evaluate TMDP 3 and TMDP 4.

2.7.1 TMDP 3

According to DEQ guidance (2001), the potential for risk exists when CPECs are present and there are complete exposure pathways between contaminated media and ecological receptors. The Level I scoping indicated that the potential for exposure exists at the Facility based on the presence of contaminated media and possible contact with receptors, resulting in the need for a Level II screening analysis. The guidance indicates that unacceptable risk is possible only if results of the Level II analysis indicated that the Facility: 1) contains any individuals of a T/E species, critical habitat of a T/E species, or contains habitat of sufficient size and quality to support a local population of non-T/E species; 2) CPECs were selected on the basis of exceedance of SLVs or because they have a high potential to bioaccumulate; and 3) there appears to be plausible links between CPEC sources and endpoint receptors (DEQ 2001).

The Level I and Level II analysis show that the Facility is an urban natural area capable of supporting local populations of non-T/E species. As discussed in the previous section, the concentrations of multiple CPECs (metals and organic chemicals) exceeded DEQ SLVs, and plausible links exist between CPEC sources and endpoint receptors. For example, vegetation developing on contaminated upland soil potentially provides a dietary source for contaminants to enter food web pathways at the Facility. However, without further risk analysis, it is unclear whether these concentrations represent unacceptable risk under Oregon rules. Additional risk analysis, would help determine whether risks are unacceptable, and/or to develop risk-based cleanup goals for the Facility.

2.7.2 TMDP 4

DEQ TMDP 4 refers to whether risk managers are willing to make response action decisions on the basis of the Level I and Level II Screening analysis alone, or whether additional risk analysis is necessary. DEQ indicated that the existing risk analysis in the BRA, which included Level I, Level II, and Level III-type analyses were inadequate to make risk management decisions, and requested additional ERA analysis for the Facility. In discussions regarding the scope of the RERA, DEQ and the Port agreed to additional analysis including expanded Level II analysis and preliminary Level III probabilistic analysis.

3.0 EXPANDED EXPOSURE AND RISK CALCUATION METHODS

3.1 Purpose and Scope

Results of the ERA Level I Scoping and Level II Screening identified some chemicals, primarily metals, PAHs, and PCBs that exceeded screening values established by DEQ. The Level II screening evaluation identified CPECs for plants, invertebrates, birds and mammals for each EU (Tables 2-2 through 2-7). The Level II SLVs are intended as screening-level estimates of soil concentrations below which no adverse impacts are expected to ecological receptors under any exposure conditions. However, they are not meant as cleanup values and exceedance of the SLVs does not necessarily indicate unacceptable ecotoxicological risk, nor should they be used as cleanup criteria (DEQ 2001). EcoSSLs were developed in a similar context (USEPA 2005a).

An expanded ecological risk analysis was conducted to provide more information on potential ecological exposures and risk at the Facility. The expanded analysis includes expanded exposure and risk calculations for representative species of small bird and mammals that may spend all, or most of their life-cycle at the facility. The expanded analysis is intended to augment the Level II analysis. The analysis also includes preliminary Level III analysis using probabilistic methods to compare risks to Oregon ARLs. This analysis is not necessarily equivalent to a Level III analysis because no data on CPEC concentrations in potential forage or prey species have been collected for the site to provide data on uptake of CPECs from soil into the local food chain. Expanded Level II assessments for birds and mammals are presented in the following sub-sections. For wildlife, exposure and risk calculations were conducted to estimate exposure of resident songbirds and small mammals that would be resident at the site, and spend all or most of their time there. Larger and more mobile species are likely to have less contact with contaminated soils and other media at the site. Therefore, risk management decisions made on the basis of songbird and small mammals will be protective of other wildlife species.

To conduct the analysis, exposure parameters (e.g., food intake rates, body size, diet) from representative species were used to represent a broad range of potential receptor species. The exposure parameters for the American robin (*Turdus migratorious*) and short-tailed shrew (*Blarina brevicauda*) were adopted for this analysis because the exposure parameters are well-known and widely used in ecological exposure assessments. Other species are likely present at the site, but the parameters used will result in an analysis that is protective of a broad range of species.

CPEC concentrations in soils also exceeded SLVs for invertebrates and plants at individual locations at the site. The locations are mapped in Figures 2-8 through 2-16 and no additional risk analysis was conducted for these receptors.

3.2 Problem Formulation for Expanded Exposure and Risk Calculations

According to DEQ guidance, the Problem Formulation should identify assessment endpoints that link the risk assessment to management concerns, and a CSM that describes key relationships between CPECs and assessment endpoint(s) and the analysis plan. The scope of the analysis is based on results of the screening analysis presented, and is intended to evaluate the potential risk from CPECs to terrestrial receptors at the Facility. The following summarizes the scope of the analysis approach.

3.2.1 Assessment Endpoints and Analysis Objectives

Small songbirds and mammals, such as mice, voles, and shrews, may spend all or most of their time at the Facility, feeding on vegetation and invertebrates that are in close contact with soils. Ground-feeding species with small home ranges represent the potentially most exposed ecological receptors, and the receptors on which risk assessment and risk management decisions are most likely to be based. The American robin was identified as the representative omnivorous avian receptor because it has relatively restricted feeding ranges during its time of residence at a site (i.e., high potential for exposure to site-specific conditions), and feeds on a variety of food items (i.e., vegetation and invertebrates) that could contact affected soils. Exposure for the American robin was estimated for both an entirely invertebrate diet, and a more omnivorous diet that includes vegetation.

Short-tailed shrews are primarily insectivorous, feeding mostly on adult and larval stages of a wide range of soil invertebrates. Shrews also have small home ranges, typically smaller than most of the EUs for the Facility (except Wharf Road EU). Other small mammals, such as mice and voles have similarly small home ranges, but have more omnivorous diets that include seeds and vegetative materials. Exposure to small mammals was estimated based on the body size, food ingestion rates, and other exposure parameters of short-tailed shrews (EPA 1993). Exposures were estimated for a diet comprised entirely of invertebrates and an omnivorous diet that includes vegetation.

The following assessment endpoints were identified for the expanded analysis:

- Survival, growth, and reproduction of resident songbirds; and
- Survival, growth, and reproduction of resident small mammals.

The overall goal of the analysis (i.e., the risk hypothesis) is to evaluate the potential exposure of the representative receptors beyond the screening-level approach defined above. The analysis includes estimation of exposure from ingestion of food and soils from the site, and comparison of the exposure estimate to intake-rate based Toxicity Reference Values (TRVs) that represent exposures that are assumed to be below unacceptable risk levels. This is a deterministic evaluation conducted to evaluate the effects of assumptions about CPEC bioavailability and uptake into forage and prey items.

For some CPECs, probabilistic analysis was conducted to allow comparison to Oregon ARLs for non-T/E species (DEQ 2001). However, the sample size available for some EUs at the Facility is small and did not allow reasonable interpretation of probabilistic analysis results.

3.3 Exposure and Risk Analysis Methods

The goal of the exposure and risk analysis is to estimate exposure of representative receptors to CPECs relative to ARLs for the local populations (for non-T/E species). The exposure and risk analysis was conducted using methods that are consistent with DEQ Level III guidance (DEQ 2001) and US EPA guidance (EPA 1997, 2005a) for each of the EUs. The specific methods, exposure parameters, ecological benchmark values (EBVs), and risk characterization methodology are presented in the following sections.

Exposure of the representative receptors was estimated using CPEC concentrations in soils to estimate concentrations in food items (i.e., vegetation, insects) for the modeled receptors. Since no data on biological tissue were available, CPEC concentrations in food were estimated using empirically derived uptake relationships from ecotoxicological literature. The resulting exposure estimates were intake ratios i.e. (mg CPEC ingested/kg body/day) and compared to EBVs.

3.3.1 Exposure Analysis Methods

The goal of the exposure analysis is to estimate the rate at which representative receptors are exposed to CPECs in the area under consideration, which is called the contaminated area (CA) in DEQ guidance. In this case, the EUs were evaluated separately as the CA. Estimating exposure for the endpoint receptor population requires defining exposure parameters (e.g., feeding range, body size, food ingestion rates) and estimating the EPC. Estimating the EPC, which is the dose of a hazardous substance occurring at a location of potential contact between an ecological receptor and the hazardous substance, is the focus of an exposure analysis (DEQ 2001). The parameters used to calculate the EPC for the representative receptors are presented below.

3.3.1.1 Exposure Estimation Model

Exposure of the representative avian receptors was estimated by calculating the daily intake of CPECs that could be ingested with food and soil at the Facility. Table 3-1 outlines the intake equations and parameters used to calculate the estimated CPEC intake for American robins (and similar terrestrial birds with omnivorous diets) and Table 3-2 for the short-tailed shrew.

Standard dietary intake equations were used to estimate the amount of individual CPECs that a receptor could obtain from ingestion of plant and/or animal tissue. Daily rates for intake of forage, prey, water, and incidental ingestion of soils were obtained from the EPA, DEQ, and other state guidance (EPA 1993 and WDOE 2012).

Since no site-specific data on biological tissue were available, CPEC concentrations in food were estimated using empirically derived uptake relationships from ecotoxicological literature (i.e., Bechtel-Jacobs 1998, and Sample et al. 1999 as recommended in EPA 2005a). In addition to the ingestion of CPECs accumulated in food items, robins or shrews may also be exposed to CPECs through the inadvertent ingestion of surface soil while foraging.

The assimilation efficiency or bioavailability of CPECs in ingested soils or biota was conservatively assumed to be 100%, except for lead. This is a conservative estimate since the bioavailability of most metals is less, especially directly from incidentally ingested soils or soils in gut content of prey items. Lead bioavailability from soils was assumed to be 50%; lead bioavailability from ingested food was assumed to be 100%. These assumptions are conservative in that actual lead bioavailability can be much lower, especially from inorganic forms of lead ore or mill tailings (Ruby et al. 1992), and lead iron oxides that tend to form in soils from soluble forms of lead (Suedel et al. 2006; Schoof 2003). Lead carbonates and organic forms have higher bioavailability (80%) (Suedel et al. 2006; Schoof 2003). Calculation of total intake also assumes that animals obtain 100% of exposure from areas under evaluation (i.e., area use factor equal to 100%).

Concentrations of CPECs in soils were used within site-specific exposure models to estimate the EPCs. Appendix D summarizes CPEC concentrations in soils (to 4 ft below ground surface [bgs]) at the Facility. For each CPEC, the tables show a detailed data summary, the MDC, and 90UCL of the mean concentrations. The tables present a summary of EPCs for each of the exposure units. Analytical results from the RI sampling events and subsequent sampling events were used to calculate 90UCLs using the EPA ProUCL computer program (EPA 2010, 2011). Figures 2-2 through 2-7 show sampling locations in each of the EUs. Appendix D presents the analytical results for CPECs within the Facility.

3.3.2 Ecological Response Analysis

According to DEQ (2001), population-level EBVs for non-T/E species are based on the median lethal dose or concentration (LD_{50} or LC_{50}). However, for this analysis, lowest-observed-adverse-effect-levels (LOAELs) for sub-lethal endpoints (reproduction, growth) were substituted.

Refer to Table 3-3 and 3-4 for a list of all bird and small mammal CPECs and EBVs that were used in the Level III risk estimation.

4.0 EXPOSURE ANALYSIS AND RISK CHARACTERIZATION

4.1 Methods

The expanded risk analysis was conducted for the CPECs identified in the Level II Screen for birds and mammals (Table 4-1). Results of the exposure calculation and comparison to the EBVs are shown for each of the EUs in Table 4-2 through 4-13 for birds and small mammals. Results based on both the discrete- and composite sample-based 90UCLs are presented. In addition, an estimate of exposure from regional background levels was also calculated for comparison purposes. A toxicity quotient (TQ) was calculated as the ratio between the estimated exposure and the EBV (DEQ 2001):

$$TQ = \text{exposure estimate}/EBV$$

DEQ does not have specific guidance for interpreting the results of deterministic exposure analyses such as that shown for the 'expanded' Level II analysis. Interpretation of results depends, in part, on how conservative the exposure parameters are compared to those used to generate NOAELs and LOAELs. In most ecological risk assessment contexts, NOAEL-based TQs equal to or less than 1.0 indicate that no adverse effects are expected (i.e., *de minimis* risk) and no further risk analysis is necessary to support site risk management decisions (see for example, USEPA 1997). NOAEL TQs greater than 1 do not necessarily indicate unacceptable risk, but that additional risk analysis may be necessary to support risk management decisions. LOAEL TQs greater than 1 also may not necessarily equate to unacceptable risk, but indicate that sensitive individuals in a population may be affected. At exposures increasingly greater than the LOAEL, a greater number of individuals could be affected, and if exposures are high enough, or widespread enough, adverse impacts on populations could occur.

In the absence of threatened or endangered species, risk from a given CPEC was considered potentially unacceptable if exposure estimates exceeded the LOAEL EBVs (i.e., TQ>1). This approach is consistent with EPA guidance and DEQ ARLs. The following discusses the expanded exposure and risk analyses separately for birds and mammals.

For some CPEC/EU combinations, a probabilistic analysis was conducted to help evaluate risk. The analysis was based on the DEQ guidance for Level III ERA, and specifically to compare probability that 20 percent of a population has a 10 percent or greater chance of exceeding a LOAEL EBV. The same exposure parameters used in the deterministic analysis were used for the probabilistic analysis. The DEQ guidance and Oregon ARL for non-T/E species is based on exceeding exposures that result in death for 50 percent or more of test samples (i.e., LD50 or LC50). Specific methods for this analysis are presented in Appendix E. However, reliable LD50 values are generally not available for chronic, oral-based exposures in experimental design. As a result, sublethal LOAELs are used as the EBV for this analysis.

4.2 Risk Characterization Results – Birds

Results of the expanded exposure and risk analysis are shown in Tables 4-2 – 4-7. Exposure estimates for one or more of the CPECs identified in Table 4-1 exceeded LOAELs in each EU. Results are discussed for each EU below. In general, the exposure estimates associated with invertivorous diet were higher than for the omnivorous diets. This is generally due to the higher uptake rates expected for invertebrates compared to plants.

4.2.1 West Parcel

Lead was the only CPEC identified from the Level II screen for this EU. The LOAEL-based TQ exceeded 1 for both the omnivorous and invertivorous diets (Table 4-2). Evaluation of the data used to calculate 90UCLs indicates that the TQ>1 was due to the influence of the maximum concentration (95 mg/kg at TP-3). If this value is removed, the TQ associated with the next highest concentration is less than 1 (0.7 for invertivorous; 0.6 for omnivorous). This result suggests that risk from lead exposure throughout much of the West Parcel is generally lower than LOAELs, only higher concentrations in the TP-3 area correspond to TQ values greater than 1.

4.2.2 Central Parcel

Expanded exposure analysis was conducted for copper, lead, and zinc in the Central Parcel EU. Results are shown in Table 4-3.

Copper exposure exceeded the LOAEL EBVs for both discrete and composite sample types (Table 4-3). Level III probabilistic analysis conducted for copper indicate that risks exceed the Level III ARL for non-T/E species (Appendix E-2-1, discrete and E-2-2, composite). The soil concentration that corresponds to a TQ of 1 for an invertivorous diet is about 223 mg/kg. Concentrations exceeding this level were observed at several locations in the EU.

Lead exposure also exceeded the LOAEL EBVs for both discrete and composite sample types (Table 4-3). Level III probabilistic analysis conducted for the lead indicates that risks exceed the Level III ARL for non-T/E species (Appendix E-2-3, discrete and E-2-4, composite). The soil concentration that corresponds to a TQ of 1 for an invertivorous diet is about 34 mg/kg. Concentrations exceeding this level were observed at several locations in the EU.

Zinc exposures did not exceed the LOAEL for birds, indicating that risks to birds from zinc exposure do not exceed acceptable levels (Table 4-3).

4.2.3 East Parcel

Expanded exposure analysis was conducted for copper, lead, Aroclors, and zinc in the East Parcel EU. Results are shown in Table 4-4.

Copper 90UCL concentrations for discrete and composite samples result in exposure estimates that exceed the LOAEL EBVs. Level III probabilistic analysis conducted for copper indicate that risks exceed the Level III ARL for non-T/E species (Appendix E-3-1, discrete and E-3-2, composite). The exceedance of the TQs was driven primarily by samples from a relatively small portion of the East Parcel EU. For both discrete and composite samples, data from the SSL riverbank samples were responsible for exceeding the LOAEL and the Level III ARL. Copper concentrations in all other samples were below 223 mg/kg, which is the concentration that corresponds to a TQ of 1.0 for the insectivore diet.

Lead exposure also exceeded the LOAEL EBVs for both discrete and composite sample types, and Level III probabilistic analysis indicates that lead risks exceed the Level III ARL for non-T/E species (Appendix E-3-3, discrete and E-3-4, composite). The soil concentration that corresponds to a TQ of 1 for an invertivorous diet is about 34 mg/kg. Concentrations exceeding this level were observed at several locations in the EU.

For Aroclors, exposures exceeded a TQ of 1 when the EPC was based on composite samples (TQ = 14, n = 8), but not when it was based on discrete samples (TQ = 0.44, n = 15; Table 4-4). However, for composites, the TQ exceeded 1.0 only when samples from the Trench 1/2 and Trench 3/4 were included. These samples were not from surface soils, but were from depths of 8 to 8.5 feet below ground surface. The samples were included based on DEQ request since surface PCB samples were not available for the Trench areas (Port/DEQ correspondence, Appendix A). As a result, Aroclor exposure based on surface soil samples from the East Parcel do not appear to exceed acceptable risk levels.

Zinc exposures did not exceed the LOAEL for birds, indicating that risks to birds from zinc exposure do not acceptable levels (Table 4-4).

4.2.4 Inner Cove Beach Exposure Unit

Expanded exposure analysis was conducted for barium, copper, lead, mercury, vanadium, zinc, and Aroclors for the Inner Cove Beach EU. Results are shown in Table 4-5.

Barium exposures did not exceed the LOAEL for birds, indicating that risks to birds from zinc exposure do not exceed acceptable levels.

The copper 90UCL concentration for discrete samples results in exposure estimates that exceed the LOAEL EBV (TQ = 3.3). Probabilistic analysis using discrete samples indicates that the risk from copper exceeds the Level III ARL (Appendix E-4-1, discrete) but does not exceed for composite samples (Appendix E-4-2, composite). A 90UCL could not be calculated for composite samples, but the maximum concentration among composites (130 mg/kg) did not exceed 223 mg/kg, which corresponds to an exposure TQ of 1.0 for insectivore diets for birds. This suggests that risks from copper might not exceed acceptable levels in the Inner Cove Beach EU if composites are considered more representative of exposures than discrete samples.

The lead 90UCL concentration for discrete samples result in exposure estimates that exceed the LOAEL EBVs. Probabilistic analysis using discrete samples indicates that the risk from lead exceeds the Level III ARL (Appendix E-4-3, discrete) but does not exceed for composite samples (E-4-4, composite). All of the discrete samples were either equal to or greater than the

34 mg/kg concentration that corresponds to an exposure TQ of 1.0 for insectivore diets for birds. A 90UCL could not be calculated for composite samples, but two of the three composites samples exceeded 34 mg/kg, but were from deep subsurface (8-8.5 ft bgs) samples collected from Trench 1/2 and Trench 3/4.

The mercury 90UCL concentration for discrete samples result in exposure estimates that exceed the LOAEL EBV. Probabilistic analysis using discrete and composite samples indicates that the risk exceeds the Level III ARL (Appendix E-4-5, discrete and E-4-6 composite). The highest concentrations were from the Wharf Road beach area. Without these samples, the maximum concentration (0.24 mg/kg) corresponds to a TQ of approximately 1.5. Composite samples were available only from deep subsurface in the trench areas on the beach. These results suggest that mercury exposure is elevated, but the primary source of exposure in the exposure unit is relatively restricted in the Wharf Road beach sampling area.

The 90UCL for total Aroclor concentrations correspond to substantially elevated TQ values (Table 4-5). However, the high TQ values are almost entirely due to samples from the Trench 1/2 and 3/4 samples collected from eight feet below the ground surface. These samples do not represent surface exposures, but were included at DEQ request because no surface samples were available from the trenched areas. Only one other detected concentration was observed from the exposure unit (0.0024 mg/kg), and corresponds to a TQ less than 1.0.

Vanadium data were available only from discrete samples from the Wharf Road beach area. Concentrations correspond to TQs approximately equal (TQ = 1.1, insectivore) to the LOAEL.

Zinc exposures did not exceed the LOAEL for birds, indicating that risks to birds from zinc exposure do not exceed acceptable levels.

4.2.5 Central Beach Exposure Unit

Expanded exposure analysis was conducted for cadmium and lead for the Central Beach EU. Results are shown in Table 4-6.

The MDC for cadmium did not correspond to exposures that exceeded the LOAEL for birds, indicating that risks to birds from cadmium exposure do not exceed acceptable levels.

No 90UCL lead concentration could be calculated for either discrete or composite samples due to small sample size. The MDC (72 mg/kg) corresponds to an exposure that exceeds the LOAEL for both the insectivore and omnivorous diet. Two of four available discrete samples, and one of two composites, exceeded the 34 mg/kg concentration that corresponds to an exposure TQ of 1.0 for insectivore diets for birds.

4.2.6 Wharf Road Exposure Unit

Dioxin TEQ was the only CPEC evaluated for the Wharf Road EU. Results are shown in Table 4-7. The Wharf Road EU is defined by the three multi-incremental sampling DUs developed for assessing the potential concentrations of PCDD/Fs in soils in the area formerly occupied by the access road from the upland area to the St. Johns dry docks. The area is small (~0.34 acres) and does not constitute an area large enough to support small birds or mammals. However, risk calculations were performed using the PCDD/F data From the DUs. The MDC and average concentration among the three DUs correspond to TQs greater than 1.0. Because of the small sample size and the small area, no probabilistic analysis was conducted for this EU.

4.3 Risk Characterization Results – Mammals

Results of the expanded exposure and risk analysis for mammals are shown in Tables 4-8 – 4-13. Exposure estimates exceeded LOAELs for one or more of the CPECs in all EUs except the West Parcel (Table 4-1). Results are discussed for each EU below.

4.3.1 West Parcel

No CPECs were identified from the Level II screen for mammals (Table 4-8).

4.3.2 Central Parcel

Expanded exposure analysis was conducted for antimony, copper, lead, zinc, and HPAHs in the Central Parcel EU. Results of the Level II analysis are presented in Table 4-9.

The 90UCL for antimony in composite soil samples was below background. For discrete samples, the 90UCL for soils corresponds to a LOAEL TQ of about 2.7 for the insectivore diet

(1.5 for the omnivore diet). The LOAEL TQ associated with background is 1.5 for the omnivore diet. Antimony concentrations exceeding background were only associated with the riverbank sampling areas WC, SSS and SSV. Composite samples include the same riverbank sampling areas, but reflect a lower overall concentration that is below background. As a result, although some discrete sampling locations exceed background, the overall concentration reflected in composite samples appears to result in exposures below the LOAEL.

Copper exposure exceeded the LOAEL EBVs for both discrete and composite sample types. Level III probabilistic analysis conducted for copper indicates that risks exceed the Level III ARL for non-T/E species (Appendix E-5-3, discrete and E-5-4, composite). The soil concentration that corresponds to a TQ of 1 for an invertivorous diet is about 401 mg/kg. Concentrations exceeding this level were observed at several locations in the EU, but the highest concentrations were at TP-34 and riverbank sampling locations SSV and SSP.

Lead exposure also exceeded the LOAEL EBVs for both discrete and composite sample types. Level III probabilistic analysis conducted for lead indicates that risks exceed the Level III ARL for non-T/E species (Appendix E-5-5, discrete and E-5-6, composite). The soil concentration that corresponds to a TQ of 1 for an invertivorous diet is about 129 mg/kg. Concentrations exceeding this level were observed at several locations in the EU.

Zinc exposures exceeded the LOAEL for insectivore diet for both discrete and composite samples, but omnivore diet TQs were less than 1.0. However, the insectivore TQs associated with the 90UCLs were not over 1.4 indicating relatively low risk overall. The highest concentrations were associated with TP-34 and riverbank sampling locations SSS, SSV, and SSP. The MDC (1,460 mg/kg) results in a relatively low TQ of 2.0. Overall, risk to mammals from zinc is relatively low in the Central Parcel EU.

HPAH exposures exceeded the LOAEL for insectivore and omnivore diets for both discrete and composite samples. The composite TQ (2.3) is substantially lower than the TQ for discrete samples (10.2), suggesting that average exposures have much lower potential risk to small mammals. The overall concentration associated with a LOAEL TQ of 1.0 is approximately 5.6 mg/kg. Ten of the 33 locations sampled for HPAHs exceeded this value, and the locations are concentrated in one area of the EU, suggesting that a portion of the EU has potential for unacceptable risk.

4.3.3 East Parcel

Expanded exposure analysis was conducted for antimony, copper, lead, Aroclors, and zinc in the East Parcel EU. Results are shown in Table 4-10.

Antimony 90UCL concentrations for discrete and composite samples result in exposure estimates that exceed the LOAEL EBVs for both the insectivore and omnivore diets. Level III probabilistic analysis indicates that risks exceed the Level III ARL for non-T/E species (Appendix E-6-1, discrete and E-6-2, composite). The exceedance of the TQs and the Level III ARL was driven primarily by samples from the SSL riverbank samples. Antimony concentrations in all other samples were below 2.7 mg/kg, which is the concentration that corresponds to a TQ of 1.0 for the insectivore diet. Background antimony concentration (4 mg/kg) also exceeded the LOAEL EBV for the insectivore diets.

Copper 90UCL concentrations for discrete and composite samples result in exposure estimates that exceed the LOAEL EBVs for both the insectivore and omnivore diets. Level III probabilistic analysis conducted for copper indicates that risks exceed the Level III ARL for non-T/E species (Appendix E-6-3, discrete and E-6-4, composite). The exceedance of the TQs and the Level III ARL was driven only by very elevated concentrations in the SSL riverbank samples. Copper concentrations in all other samples were below the 400 mg/kg concentration that corresponds to a TQ of 1.0 for the insectivore diet.

Lead exposure also exceeded the LOAEL EBVs for both discrete and composite sample types. Level III probabilistic analysis indicates that lead risks exceed the Level III ARL for non-T/E species (Appendix E-6-5, discrete and E-6-6, composite). The soil concentration that corresponds to a TQ of 1 for an invertivorous diet is about 129 mg/kg. Concentrations exceeding this level were observed at several locations in the EU.

For Aroclors, exposures exceeded a TQ of 1 for discrete and composite samples. However, the initial EPCs include samples from Trench 3/4, which is not from surface soils, but were from depths of 8 to 8.5 feet below ground surface. The samples were included based on DEQ request since surface PCB samples were not available for the Trench areas (Port/DEQ correspondence, Appendix A). When this sample is excluded from the data set, TQs are less than 2.0.

Zinc exposures exceeded the LOAEL for insectivore diet for both discrete and composite samples, but at 1.5 the TQ was relatively low. The omnivore diet TQs were less than 1.0 for both discrete and composite samples. The highest concentrations were associated with the riverbank sampling locations in the SSL area. Overall, risk to mammals from zinc is relatively low in the East Parcel EU.

4.3.4 Inner Cove Beach Exposure Unit

Expanded exposure analysis was conducted for antimony, copper, lead, Aroclors, HPAHs, and zinc in the Inner Cove Beach EU. Results are shown in Table 4-11.

The antimony 90UCL concentration for discrete samples results in exposure estimates that exceed the LOAEL EBVs for both the insectivore and omnivore diets. Level III probabilistic analysis indicates that risks exceed the Level III ARL for non-T/E species (Appendix E-7-1, discrete and E-7-2, composite). Two of nine total discrete samples have concentrations above background. Two of the three composite samples available for the EU were from deep subsurface samples (8-8.5 ft bgs). The exceedance of the TQs and the Level III ARL was driven primarily by samples from the Beach Cove 1 location (154 mg/kg). The background antimony concentration (4 mg/kg) also exceeded the LOAEL EBV for the insectivore diets.

The copper 90UCL concentration for discrete samples results in exposure estimates that exceed the LOAEL EBV for invertivorous (TQ = 1.9), but not the omnivorous diet. Level III probabilistic analysis indicates that risks exceed the Level III ARL for non-T/E species for discrete samples but not for composite samples (Appendix E-7-3, discrete and E-7-4, composite). A 90UCL could not be calculated for composite samples, but the maximum concentration among composites (130 mg/kg) did not exceed 400 mg/kg, which is the concentration that corresponds to an exposure TQ of 1.0 for insectivore diets for small mammals.

The lead 90UCL concentration for discrete samples results in exposure estimates that exceed the LOAEL EBVs. Probabilistic analysis using discrete samples indicates that the risk from lead exceeds the Level III ARL (Appendix E-7-5, discrete and E-7-6, composite). Four of the ten discrete samples were either equal to or greater than the 129 mg/kg concentration that corresponds to an exposure TQ of 1.0 for insectivore diets for small mammals. The three composite samples available for the EU ranged from 30 to 137 mg/kg, but two of the samples were from deep subsurface samples (8-8.5 ft bgs).

The 90UCL for total Aroclor concentrations correspond to substantially elevated TQ values. As described for bird exposure in this EU, the high TQ values are almost entirely due to samples from trenches at eight feet below the ground surface. These samples do not represent surface exposures, but were included at DEQ request because no surface samples were available from the trenched areas. Only one other detected concentration was observed from the exposure unit (0.0024 mg/kg), and corresponds to a TQ less than 1.0. The highest concentrations were associated with the shoreline sampling adjacent to the Wharf Road area.

HPAH exposures exceeded the LOAEL for insectivore and omnivore diets for discrete samples. Probabilistic analysis using discrete samples indicates that the risk from lead exceeds the Level III ARL (Appendix E-7-7, discrete and E-7-8, composite). Two of the three composite samples available for the EU were from deep subsurface samples (8-8.5 ft bgs), and no UCL was calculated for these samples. The overall concentration associated with a LOAEL TQ of 1.0 is 5.6 mg/kg. None of the composite samples exceeded this concentration, while two of the six discrete samples exceeded it.

Zinc exposures exceeded the LOAEL for insectivore diet for discrete samples, but the TQ was 1.3 indicating relatively low risk. The omnivore diet TQs were less than 1.0 for discrete samples. The highest concentrations were associated with the shoreline sampling adjacent to the Wharf Road area.

4.3.5 Central Beach Exposure Unit

Expanded exposure analysis was conducted for cadmium in the Central Beach EU. The MDC for cadmium corresponds to exposures that exceeded the LOAEL for small mammals, with a TQ of 1.7 (Table 4-12). All other detected cadmium concentrations were below background.

4.3.6 Wharf Road Exposure Unit

As was done for birds, dioxin TEQ was the only CPEC evaluated for the Wharf Road EU. The Wharf Road EU is defined by the three multi-incremental sampling DUs developed for assessing the potential concentrations of PCDD/Fs in soils in the area formerly occupied by the access road from the upland area to the St. Johns dry docks. The area is small (~0.34 acres) and does not constitute an area large enough to support small mammals or other wildlife. Risk calculations were performed using the PCDD/F data From the DUs. The MDC and average concentration among the three DUs correspond to TQs greater than 1.0. Because of the small sample size and the small area, no probabilistic analysis was conducted for this EU.

4.4 Hot Spot Analysis

Highly concentrated hot spot levels were calculated for species not listed as threatened or endangered in accordance with DEQ guidance (DEQ 1998, 2001) for each of the chemicals for which exposures exceeded ARLs at the site. Table 4-14 shows generic high concentration hot spot levels calculated for the relevant chemicals, based on values that correspond to fifty times the lowest Level II SLV for ecological receptors (From Table 1, DEQ 2001). Figure 4-1 shows the sampling locations at which concentrations of one or more COCs exceed the hot spot concentrations. Hot spot concentrations were identified for copper, lead, mercury, Aroclors, and dioxins. No hot spots were identified in the West Parcel EU, but at least one location was identified in the other EUs.

Hot spots were also evaluated for wildlife based on probabilistic analysis. The analysis was conducted for copper, lead, and mercury for the Central Parcel, East Parcel, and Inner Cove Beach EUs. Analysis was not conducted for Aroclors or dioxins because only one location was identified by generic hot spot analysis for each chemical. In addition, the generic hot spot location for Aroclors was associated with a deep subsurface sample from the Trench 4B location. The analysis was not conducted for the West Parcel because no hot spots were identified based on the generic hot spot analysis shown in Figure 4-1. No analysis was appropriate for the Central Beach EU because insufficient data was available (i.e., only two sampling locations available for these chemicals).

The probabilistic risk analysis was conducted only for birds because they are more sensitive than mammals for these COPCs (i.e., the EBVs for birds are generally lower than for mammals). As with the previous evaluations, the analysis was conducted separately for discrete and composite samples and the same exposure parameters were used. Hot spot threshold levels were defined as greater than a 10% chance that 20% of the population would experience exposures greater than 10x the LOAEL. This is consistent with DEQ (1998) guidance which defines the hot spot levels for non-T&E species as a greater than 10% chance that 20% of the population would experience a TQ of 10.

The overall results are shown in Table 4-15, and detailed analysis is shown in Appendix F. Copper exposures exceed hot spot levels only in the East Parcel EU, and only for discrete samples. Lead exposures exceed hot spot levels in all three EUs. Mercury hot spot exposures were identified only for the Inner Cove Beach EU.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Extensive investigations of soils and groundwater at the Facility indicate that some areas of the site contain elevated concentrations of metals, HPAHs, Aroclors, and TCDD/Fs. For plants and invertebrates, CPEC concentrations in soils exceed DEQ SLVs at multiple sampling locations. Except for the eastern Central Parcel, locations with concentrations exceeding SLVs are widely dispersed and do not represent contiguous areas where a significant portion of the habitat is affected. The highest potential for unacceptable risk is associated with metals at several adjacent sampling locations in the eastern Central Parcel (e.g., TP-9, TP-31). In addition, elevated concentrations of metals (lead, mercury) are located at the shoreline areas in the downstream portion of the Inner Cove EU. However, these sampling locations are near or at low water line and are inundated much of the time. Qualitative observations in these areas reveal that no permanent plant or soil invertebrates are present, probably due to the natural effects of inundation and wave action. Therefore, risk management action in these areas to protect upland plants and/or invertebrates would not be effective in reducing risk.

Without site-specific toxicity testing for plants or invertebrates, conclusions about the relative risk to these groups is uncertain, especially if assessing overall ecological function. As noted in Section 2, no overtly phytotoxic areas were observed on site visits. Soil conditions including pH, organic carbon content, texture and other factors are known to affect bioavailability and toxic potential. Overall, data suggest that soil CPEC concentrations may be toxic to plants or invertebrates at some locations, but the overall effect on populations or communities, or the corresponding function are not known. For this reason, the use of Level II SLVs for assessing the potential for ecologically meaningful adverse effects on plants and invertebrates should be considered highly conservative. It is the Port's opinion that the existing data and information about the site do not support active remediation to protect plants or invertebrates.

Elevated CPEC concentrations in soils can lead to increased uptake into plants and invertebrates, and subsequent exposure to wildlife that feed on them. No data on CPEC concentrations in biota were available, so empirical uptake equations from the scientific literature were used to estimate potential biotic uptake of CPECs. Extrapolation from literature-based equations represents a significant source of uncertainty in estimating exposure and risk. The literature equations are typically developed for screening-level purposes, so there is little chance of underestimating risk. The results were used to assess potential exposure and risk to representative wildlife species.

Elevated concentrations of copper and lead were the most widespread among the EUs. Potential risks from copper and lead were the most prevalent and widespread for both birds and mammals (Table 4-1). Elevated antimony concentrations also result in potentially unacceptable risk for mammals in the Central Parcel, East Parcel, and Inner Cove Beach EUs. For the Inner Cove Beach EU, the metals mercury, vanadium and zinc were present at levels that could result in unacceptable risk for mammals and/or birds.

Exposure of birds and mammals to Aroclors was also potentially unacceptable in the East Parcel EU and Inner Cove Beach EU. However, the highest concentrations of Aroclors were detected in subsurface (8-8.5 ft bgs) samples in the Trench 1/2 and 3/4 sampling locations. These samples were included in the risk analysis at DEQ's request because no Aroclor results were available for surface soils in these sampling areas. When these samples are excluded from the exposure analysis, the remaining Aroclor concentrations correspond to TQs above 1.0 but less than 2.0, indicating relatively low risk.

Except for copper and lead, the exposure exceeds the EBVs primarily due to a few locations with exceptionally high concentrations. In several cases, the most elevated concentrations are from samples that are in close proximity to each other. Examples include PCBs from the Trench samples cited above; dioxin and PCB in Riverbank sampling areas SSS, SSL, SSV; and mercury, copper, and lead in the shoreline sampling locations in the downstream part of the Inner Cove Beach EU. In most cases, sampling has been focused on the areas suspected of contamination, so the more highly sampled areas are overrepresented in the exposure calculations, and the risk calculation is not representative of habitats throughout the EU.

Exposure of upland songbirds and small mammals in the Central Beach and Inner Cove Beach EUs may not be representative of actual exposures for several reasons, but primarily that there are no habitat or food resources for such species in aquatic areas. The PH-BERA includes risk analysis for wading birds in both of these areas. The PH-BERA analysis does not include upland samples collected for the Willamette Cove Facility; analysis was conducted using composite soil samples collected along the beaches in areas typical of where wading birds feed. No unacceptable risks were identified for the Central Beach area. Exposure to PCB and copper risks exceeded LOAEL benchmarks in the Inner Cove Beach area. However, the exposure estimates for the PH-BERA were based on chemical concentrations in aquatic invertebrate samples collected from within the Willamette River. As a result, the sources of copper and PCBs in the invertebrates cannot be attributed to the Willamette Cove Facility.

Based on the results presented in this RERA, ecological receptors at the Facility could experience toxic exposures to CPECs if they spend enough time in areas of the highest concentrations. If the exposure and risk is determined to be unacceptable, focused remedial action in areas of high concentrations could lower exposure estimates to levels that would be below Oregon ARLs. Consistent with Oregon statute, a Feasibility Study (OAR 340-122-0085) is recommended to help determine whether remediation or other risk management actions would be effective in reducing risk at the site.

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